Components of a Groundwater Monitoring Strategy for the State of Wisconsin

Introduction

The State of Wisconsin, in cooperation with the United States Geological Survey (USGS), monitors groundwater to meet the diverse needs of the different state agencies that have groundwater protection and management responsibilities (Table 1). Representatives from the Department of Natural Resources (DNR), Department of Agriculture Trade and Consumer Protection (DATCP), Wisconsin Geological and Natural History Survey (WGNHS), USGS, Central Wisconsin Groundwater Center (CWGC) and the Wisconsin Academy of Sciences, Arts, and Letters, reviewed existing monitoring programs and determined a common strategy for groundwater monitoring programs in the state. Use of the strategy by local, state, and federal agencies and by researchers will allow for better data management and sharing, a common protocol for collecting high quality groundwater data and expansion of the fixed monitoring network. The fixed monitoring stations will be available for groups or individuals willing to share analytical data from samples collected from the monitoring locations. The resulting high quality data will be available on the Groundwater Coordinating Council (GCC) web site maintained by the DNR.

Table 1: Agencies that Monitor Groundwater in Wisconsin

Agency	Groundwater Monitoring Programs
Department of Commerce	Petroleum Environmental Cleanup Fund Act (PECFA)
CWGC	Research, outreach and private well sampling
DATCP	Pesticide and nutrient monitoring and evaluation of atrazine rule
DNR	Public and private water supply, landfill and contaminated site monitoring, Wisconsin Pollution Discharge Elimination System permitted sites (WPDES), special studies, surface water monitoring stations
Department Of Transportation	Highway salt contamination along right of ways
State Laboratory of Hygiene	Private wells sampling and research
USGS	National Water Quality Assessment (NAWQA), special studies, groundwater level network, surface water monitoring stations
WGNHS	Special studies, groundwater level network

Purpose

Implementation of the Clean Water Act (CWA), Wisconsin's Groundwater Law (Chapter 160 Wisconsin Statutes) and recently enacted groundwater quantity legislation (2003 Act 310) all require an understanding of groundwater systems that involves monitoring. The Clean Water Act gives Wisconsin DNR primary responsibility for protecting and restoring water quality including monitoring and assessing the state's waters and reporting on their quality. Chapter 160 of the Wisconsin Statues requires the DNR to work with other agencies and the GCC, to develop and operate a system for monitoring and sampling groundwater to determine whether harmful substances are present (s. 160.27, Wis. Stats.). 2003 Wisconsin Act 310 directs the DNR to issue well approvals and track water

use for high capacity wells. The objective of the monitoring strategy is to coordinate groundwater monitoring between all agencies interested in groundwater quality, quantity and use in Wisconsin.

Overview

This report is the result of discussions by state and federal agencies on coordinating groundwater-monitoring efforts in the State and consists of goals, components, a possible implementation strategy and potential partners and funding sources. Three goals have been identified by the inter-agency workgroup: 1) provide data to determine how groundwater is changing over time; 2) provide data to increase understanding of groundwater systems; and 3) provide data to citizens to increase their understanding of how their actions affect groundwater.

The workgroup identified eight components that will accomplish the goals:

1) A comprehensive assessment of existing data and databases
2) A fixed network of groundwater level monitoring locations
3) A statistically correct process for stratified random sampling of private wells for water quality parameters
4) A fixed network of groundwater quality monitoring sites
5) A fixed network of surface water monitoring stations
6) A water use reporting program
7) A common data management program
8) A common communication approach

Some of these components, such as a fixed network for groundwater level monitoring, a fixed network for surface water monitoring, and a water use reporting program already exist and are maintained by state and federal agencies. Other components such as a fixed network for monitoring groundwater quality and a data management process need to be implemented. The cost of maintaining and expanding current groundwater monitoring components is detailed below (Table 2).

The implementation strategy discussed by the workgroup consists of four phases: a baseline assessment of the shallow aquifers in each of 23 surface water basins; a baseline assessment of the deep aquifer systems; establishment of an ambient monitoring network; and planning for long term sustainability of the monitoring strategy. The ambient monitoring locations will be based on the groundwater assessments of the shallow and deep systems. Planning for long term sustainability will be dependent on needs of the partners and funding.

Finally, the strategy looks at potential partners and funding sources. A coordinated groundwater monitoring strategy will allow for a more efficient use of limited funds and better data sharing between agencies and public partners. Funding sources and partnerships will develop over time.

Goals

Goal 1: Provide and maintain sufficient, high quality groundwater data to evaluate spatial and temporal trends in groundwater quality, quantity and use

Agencies need high quality data to make changes to groundwater management and protection policies in response to changing trends in groundwater quality, quantity and use. The components used to meet this goal must be flexible enough to accommodate

new contaminants and threats as they are recognized. Examples of how the data will be used include:

1. Evaluating groundwater protection programs;
2. Evaluating public health protection programs;
3. Documenting the presence of new pollutants;
4. Assessing groundwater quality in DNR basins;
5. Tracking groundwater levels in groundwater management areas; and
6. Evaluating water use and its impacts on groundwater levels.

Goal 2: Provide high quality data for a more complete understanding of groundwater systems

An understanding of hydrogeology drives state and local policy and management decisions that affect drinking water, fisheries and wildlife habitat. Research aimed at understanding flow systems at different scales, local and regional, helps local resource managers make decisions that protect all water resources. Examples of how this data will be used include:

1. Locating and preserving groundwater recharge areas to sustain groundwater quantity;
2. Understanding the fate and transport of natural and human-induced contaminants;
3. Understanding how land use practices affect groundwater quality and flow; and
4. Developing and evaluating management alternatives.

Goal 3: Provide tools to make groundwater data accessible to citizens, policy makers and resource managers

The public's understanding of groundwater has greatly increased since the Groundwater Law was passed in 1984. The next step is to make local groundwater data easily accessible to citizens, policy makers, researchers, and resource managers so that all stakeholders have the information they need to increase protection of the resource and public health whether on a local or statewide level. To attain this goal we will:

1. Make groundwater data accessible to citizens, policy makers and resource managers via a website;
2. Develop tools to help educate citizens about statewide and local groundwater quantity and quality problems; and
3. Involve partners in groundwater monitoring to increase awareness of groundwater.

Components of the Groundwater Monitoring Strategy

These components were derived from existing monitoring programs in Wisconsin and other states and federal monitoring programs. Details about each component and the goals it addresses are presented below, along with suggested improvements.

Component 1: Mining of Existing Databases (meets goals 1 and 2)

A comprehensive look at existing data for parameters of concern is a starting point for implementing each phase of the groundwater monitoring strategy. Existing databases (Groundwater Retrieval Network, DATCP, Wisconsin Groundwater Center and others) can be mined for parameters such as major anions and cations, nitrate, chloride, arsenic and radon. Public, private and monitoring well data and their databases will be assessed. This component could be done with the assistance of partners who currently maintain existing databases. The GCC joint solicitation is a possible funding source.

This component meets goals 1 and 2 by providing baseline data for groundwater trend analysis and system research. We suggest funding a 0.5 FTE for the initial assessment and subsequent data mining.

Component 2: A Fixed Network of Groundwater Level Monitoring Locations (meets goals 1 and 2)
Monitoring will include measurement of groundwater levels in all of Wisconsin's water-bearing formations reflecting both water table conditions and deep confined and unconfined aquifers. It should include areas of groundwater development such as urban and rural areas with large withdrawals and undeveloped areas such as forestland.

The USGS and WGHNS have maintained a fixed network of monitoring wells since the 1940s, which currently includes 117 wells. The network was designed to monitor water levels in the upper most aquifers. In 2000 the USGS evaluated the network for well location, condition and presence of geologic logs. They recommended that 48 wells be abandoned and replaced by wells in different locations. The cost estimate for improving the observation well network is shown in the table below.

Well abandonment	$500/well
Real time monitoring equipment	$750/well
Siting (professional time)	$700/well
Drilling and well installation	$2000/well

The total estimated cost of $200,000 could be spread out over 3 to 5 years. Costs may be lower if existing wells can be added to the network. This new, improved observation well network will monitor water levels in shallow, unconfined aquifers in each of Wisconsin's 23 basins and improve our understanding of groundwater flow systems in each basin. This information will allow us to look at groundwater quantity trends.

Monitoring the cone of depression in areas where the water table is declining will require additional monitoring wells. These wells will be installed in the deeper bedrock aquifers and may require casing. Approximately 10 new wells will be installed at a cost of about $40,000 per well. The total estimated cost would be $400,000.00. This cost may be less if existing wells can be used. The yearly combined cost for maintaining a fixed network of 115 water table wells and 10 deep wells to monitor cones of depression will be about $120,000. This includes rehabilitating wells, training staff and replacing damaged wells.

This component meets goals 1 and 2 by providing high quality groundwater level data over a long period of time. Currently the USGS, DNR and WGNHS maintain and monitor a fixed network. Improvements to the network have been proposed above and funding is being looked at by the different agencies.

Component 3: Stratified Random Sampling of Private Wells for Water Quality Parameters (meets goals 1 and 2)
Numerous efforts have been made to characterize groundwater quality on a statewide basis. These efforts include sampling of private, public and monitoring wells. The Department of Agriculture, Trade and Consumer Protection used a statistical procedure for stratified random sampling of private wells to obtain a representative sample of all Wisconsin groundwater for pesticide analysis. The sampling protocol is statistically sound and uses a sophisticated well selection procedure to determine the extent of

monitoring within a sampling stratum. Sampling strata are defined as the geographic area of interest. Examples of strata include aquifers, watersheds, basins, or agricultural statistics districts.

Briefly, stratified random well selection works as follows: parcels are randomly selected and the well nearest the center of the parcel is selected for sampling if permission is given by the well owner. If there is no well or the owner refuses to have the well sampled, another parcel is selected by spiraling out clockwise around the original parcel. If appropriate sampling strata are used, this approach can be used to select wells for sample collection and analysis for other non-agricultural water quality parameters as well. The number of samples collected in each statistical stratum can be based on many things including prior detects, number of acres in a certain landuse or number of acres in a watershed or basin.

The DATCP pesticide surveys of 1994, 1996 and 2001 used a fifty-percent rotation scheme in which half of the wells in the 1996 and 2001 surveys were part of the previous survey and half were new wells. This allowed detection of changes in pesticide levels over time.

The cost for sample collection and analysis will vary depending on the parameters analyzed for. Based upon existing and previous monitoring efforts, we estimate the cost of this component to be $180,000.00 per year. Parameters may include major cations and anions, indicator parameters, and the contaminants of special interest. This component will meet goals 1 and 2 by providing a flexible means of looking at groundwater quality trends and better defining groundwater contaminant transfer in flow systems. The Monitoring and Data Management Subcommittee of the GCC will help better define how the data will be made accessible.

Component 4: A fixed network of water quality monitoring sites (meets goals 1 and 2)
Stratified random sampling of private wells may lead to selection of fixed monitoring sites for long term monitoring. Fixed sites chosen to consider at the effect of different land use practices will be part of the fixed network. Existing research and monitoring project wells could also be incorporated into the fixed network as well as public water supply wells (e.g. sentinel wells). Each location may have more than one well to monitor specific parameters. This network may change somewhat with time. Costs at this time are difficult to estimate.This component meets goals 1 and 2 by providing groundwater quality data in areas of concern over time. More details on this component will need to be worked out by the GCC and it's subcommittees.

Component 5: Surface water monitoring stations (meets goals 1 and 2)
Surface water monitoring stations provide stream flow data used to:
1. Calibrate groundwater flow models
2. Assess basin water resources management decisions
3. Model the effect of development on watersheds
4. Determine the effect of groundwater use on stream flow and fisheries habitat.

The USGS has evaluated the current stream gaging network and determined that 25 additional monitoring stations are needed on medium-sized streams. The cost of adding 25 new stations and maintaining them is $250,000. Proposed station locations are based on the need for stream flow data for DNR Watershed and Fisheries and Habitat

programs. An additional $70,000 per year is needed to collect low flow measurements in small streams as needed to support long-term monitoring. Funding for changes to the network is not currently available from the USGS or DNR.

This component meets the needs of goals 1 and 2 by providing long term data on groundwater baseflow to surface water at fixed locations. The USGS and DNR currently maintain a surface water monitoring network and will continue to do so. This component can be enhanced with citizen-based monitoring of small streams. Other partners have access to the data on a website.

Component 6: Water use reporting (meets goals 1 and 2)
The purpose of water use reporting is to manage groundwater at local and regional levels. Data are used to evaluate impacts of proposed wells, monitorwell approval conditions, identify trends, as input for groundwater flow models, develop hydrologic budgets for watersheds and basins and improve water use estimates. We currently have good data for municipal water supply systems but the reporting should be expanded to all high-capacity wells (>100,000 gal/day) including:

- Industrial and commercial users
- Irrigators
- Non-irrigation agricultural users

As part of the implementation of 2003 Wisconsin Act 310, high capacity wells will be required to report water use to DNR. This strategy proposes that the data be managed in a database and available on the internet through a common portal as described in Component 7.

This component meets goals 1 and 2 by providing groundwater use data to help determine water quantity trends and define groundwater/surface water interactions. New well fees may provide funding for data this collection.

Component 7: Data management (meets goals 1,2 and 3)
A “Directory of Groundwater Databases” was completed by the GCC in 1998. This publication will be updated. It will form the foundation of a meta-database available on the Internet. Metadata refers to any data used to aid the identification, description and location of networked electronic resources. As the other components of the strategy are implemented, existing and new databases related to groundwater monitoring will be added to the meta-database.

One half of an FTE will collect and maintain the metadata base and be responsible for adding new databases as necessary. The Monitoring and Data Management Subcommittee of the GCC will determine the minimum data elements and insure that data sharing occurs. The group recommends that the use of Wisconsin Unique Well Numbers be discussed as a means of tracking individual well data. The data will be available through a common portal, possibly located on the GCC website.

This component meets goals 1 and 2 by providing a mechanism for data sharing between agencies for groundwater characterizations and goal 3 by providing data to the public on groundwater in the state. We suggest that 0.5 FTE be funded within DNR to create and maintain the meta-database.

Component 8: Communication (meets goal 3)
Data and maps generated from monitoring data should be accessible. The Education Subcommittee of the GCC will determine how materials will be made available to all agencies and the public. Creation and maintenance of maps and monitoring reports will require 0.5 FTE. We suggest that the one FTE be responsible for Components 7 and 8. The total estimated cost for components 7 and 8 are $75,000.00 or 1 FTE. The Education subcommittee of the GCC will act as a clearinghouse for educational materials posted on the GCC website and derived from Components 7 and 8.

The estimated cost for the new monitoring strategy is summarized in Table 2.

Table 2: Estimated cost of Groundwater Monitoring Strategy Components

Components	One Time Cost	Yearly Cost
Water Level Monitoring	$600,000	$120,000
Water Quality Monitoring (public, private and monitoring wells)		$180,000
Stream Flow Monitoring		Varied *
Modeling groundwater flow and surface water interactions		$90,000**
Data Management and Communication		0.5 FTE=$32,500
Data Analysis/Assessment		0.5 FTE=$32,000
Reporting		0.5 FTE=$32,500
Total	$600,000	$487,500

*The cost of adding one surface water-monitoring station to the existing network is approximately $10,000.00 per station. Additional stream flow measurements in small streams to supplement gauging stations will cost approximately $70,000 per year. To evaluate the environmental impact of high capacity wells under 2003 Wisconsin Act 310, stream flow measurements will be needed.

**This is based on a proposed cost of $90,000 for a 2-year project to model the Rock (Upper and Lower) Basin and assumes projects in two basins would be running concurrently. Project basins would be selected based on hydrogeologic and groundwater use factors. Not all basins would necessarily be modeled. It would take 5-10 years for coverage of all appropriate areas of the State.

Implementation
The network will be maintained for use by the different state and federal agencies or other entities such as universities, local governments and consultants for special studies. The following four phases illustrate how the monitoring network will be implemented and used. Phases one and two will assess groundwater systems and determine fixed monitoring locations as described in phases three and four. Parts of phases 1 and 2 are completed or started for some basins or deep aquifers.

Phase I: Baseline Assessment of shallow aquifer system by 23 major basins
Most groundwater management decisions made in Wisconsin are based on data collected for other purposes and published studies done in other states. As groundwater sustainability becomes more critical it is important to use more reliable and applicable data to make groundwater and land use decisions. Assessing the condition of shallow groundwater in each basin is the first step toward groundwater sustainability. Initially, a pilot basin will be assessed to determine the best way to do a groundwater assessment for each basin. An assessment of each of the 23 basins may include the following:

- Mining of data in existing databases to determine contaminants in the basin
- Evaluating potential contaminants present in the basin due to land use
- Determining water quality in select wells (private, public, or monitoring wells) for major cations and anions and other contaminants of concern
- Modeling groundwater flow and surface water interactions
- Identifying fixed monitoring stations (surface water and groundwater) for water quality and quantity
- Evaluating water use
- Making the data and assessment public

Phase II: Baseline Assessment of Deep Aquifer Systems
The next step toward better management of Wisconsin's groundwater is evaluating the deeper aquifers. Because deeper aquifers are not impacted as quickly by land use, and because deep groundwater divides usually differ from surface water divides, it is more appropriate to evaluate across basin lines by aquifer. An assessment of deeper aquifer systems will include the following:

- Mining of data in existing databases to determine contaminants in the aquifer
- Evaluating potential contaminants due to land use
- Evaluating pathways allowing contaminants to reach deeper aquifers
- Determining water quality in select wells (private, public, or monitoring wells) for major cations and anions and other contaminants of concern
- Identifying fixed monitoring stations, including sentinel wells for water supply systems, for water quality and quantity
- Evaluating water use
- Delineating deep aquifer systems
- Making the data and assessment public

Phase III: Ambient monitoring network by basin and aquifer system
Wells useful for monitoring groundwater quality and quantity trends will be identified in phases 1 and 2. In phase 3 these wells will be sampled periodically for parameters specific to each basin or aquifer system. In addition, the wells will be available for use by other interested parties. Surface water monitoring stations will be monitored to determine trends reflected in groundwater/surface water interaction. Groundwater flow models will be updated as needed. Water use information will be a critical piece of information in determining water quantity trends. The data will be maintained by DNR and made available to the public.

Phase IV: Long term sustainability of monitoring network
The monitoring strategy must be flexible enough to reflect changes in water use, land use, and identified emerging contaminants. It is important to maintain fixed monitoring locations and to re-assess baseline evaluations periodically (every 5-10 years). The wells will be used to perform more detailed monitoring studies and serve as a basis for

developing educational resources and reports. The data will be maintained in an accessible database.

Potential Partners

Potential partners include federal, state, and local governments, universities and other entities involved in groundwater management and research. In addition, volunteers (citizens, schools and others) will have opportunities for monitoring groundwater. Data will be managed by different agencies but will have a common format and portal on the GCC website. Educational and informational materials derived from the data and developed by the partners will be available through the GCC webpage.

Funding Sources

Table 1 shows the different groundwater monitoring programs currently supported by state and federal agencies. Some of this data is suitable for inclusion in a common meta-database. An example would be DOT salt monitoring along highways. County health departments also currently sample private wells and that data may be included if appropriate. University research projects will be funded by grants with data made accessible through the GCC website.

Funding for the fixed networks would logically come from the programs they benefit. For example, federal Clean Water Act (106) and Nonpoint Source (319) grant money is allocated for monitoring. Fees collected as part of the new Groundwater Quantity legislation will support money for water use data collection. Money allocated to the Groundwater Fund of the Environmental Fund will help fund some of the stratified random sampling programs as will money allocated to DATCP for pesticide monitoring. Safe Drinking Water funds could possibly be used to look at water quality and quantity trends at fixed stations placed to determine impacts to municipal wells. New funding sources may have to be found for the data mining, data base development and maintenance and educational materials components.

One aspect of the monitoring strategy that needs further exploration is volunteer monitoring. Universities, high schools and private individuals might collect well samples. The WGNHS or USGS would provide well installation and training. This type of monitoring has been used in other states and meets both fixed monitoring and educational objectives.

Conclusions

A group representing several agencies which monitor groundwater for protection and management programs evaluated current groundwater monitoring in the state. Three common goals were determined. First, long term trends in groundwater quality and quantity must be tracked. Second, research aimed at understanding groundwater systems and how they interact with surface water is needed. Finally, the data needs to be maintained in an easily accessible common portal that provides raw data and materials geared toward public education.